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"AN AIR-BAG"

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THE PRESENT INVENTION relates to an air-bag, and more particularly relates to an air-bag of the type in which an inner gas supply tube is provided within the air-bag, the gas supply tube being adapted to be connected to a gas generator, and having apertures formed in the wall thereof to direct gas into discrete inflatable regions or chambers formed within the air-bag.

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It has been proposed to provide an air-bag which has a plurality of inflatable regions or chambers which are to be supplied with gas from a gas generator. One example of such an air-bag is a so-called "inflatable curtain" which is adapted to be mounted in the roof of the vehicle above the door openings of the vehicle, and is also adapted, when an accident occurs, to be deployed to lie adjacent the window openings formed in the door, thus forming a protective curtain located between the occupant of the vehicle and the side of the vehicle. Such inflatable curtains provide protection to the occupant of the vehicle in the event of a side impact or roll-over situation.

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US-6,199,898 B discloses a safety device of this type in which the inflatable curtain is formed of an inflatable element which is divided into a plurality of regions or chambers which are to be inflated. An internal fabric gas

supply duct is provided. That gas supply duct is provided, along its length, with circular apertures formed in the wall of the duct through which gas can flow from the duct into those regions or chambers of the inflatable element which are to be inflated.

It is conventional for the main fabric parts of the air-bag, and also the internal gas supply duct, to be cut-out from a large sheet or roll of fabric in such a way that maximum use is made of the fabric so that there is minimum wastage. The internal fabric gas supply duct is normally formed by taking an elongate strip of fabric and folding it so that the opposed edges are brought together, those opposed edges being inserted between the adjacent edges of the layers of fabric which form the main part of the inflatable curtain. The four super-imposed edges are stitched together.

Depending upon the cutting-out pattern used for cutting the main fabric parts of the air-bag and the supply duct from the sheet or roll of fabric, the axis of the gas supply duct may effectively make any angle with the warp and weft yarns of the fabric. The axis of the fabric element forming the gas supply duct may, for example, be aligned with either the warp yarns or the weft yarns. In such a case it has been found that the textile "tube" that constitutes the gas supply duct may be almost non-flexible in a radial direction. Consequently the edges of the circular apertures formed in the gas supply duct may "tear" during the inflation process. This may cause an irregular deployment of the inflatable curtain.

If the axis of the element that forms the gas supply duct is such that the warp and weft yarns each make an angle of, say, 45° to the axis, the resultant "tube" may be quite flexible in the radial direction. However, during inflation, the region of fabric around the outlets may deform or may become very

substantially "frayed" or with some of the fibres forming the fabric extending into the regions or chambers which are to be inflated. If the internal gas supply duct is not located in exactly the correct position within the inflatable curtain, this deformation of the region around the apertures may be blocked, for example by the dividing seam between two adjacent regions or chambers. Again, in this case, the deployment of the inflatable curtain may be irregular.

The present invention seeks to provide an improved air-bag .

According to the present invention, there is provided an air-bag, the air-bag defining at least one inflatable region, the air-bag being provided with a gas supply duct extending into the air-bag, the gas supply duct being formed of a flexible material and being provided with at least one aperture therein through which gas may flow into the said at least one inflatable region of the air-bag, the said at least one aperture being provided with a reinforcement reinforcing the periphery of the aperture.

Conveniently the flexible material comprises fabric or a plastic material.

Alternatively, the flexible material comprises foil.

Preferably the gas supply duct is of an elongate form.

Advantageously the gas supply duct is provided with a plurality of said apertures, each aperture being associated with a reinforcement.

Conveniently the or each aperture is provided with a respective reinforcement.

Preferably the or each of the reinforcement is stitching provided in the flexible material forming the gas supply duct.

Conveniently the or each reinforcement comprises a length of thread extending across the or each respective aperture so as to tie together opposing parts of the or each aperture.

Advantageously the reinforcement for the or each aperture is a respective annular reinforcing element.

Conveniently the reinforcement is a single reinforcing element defining a plurality of apertures.

Preferably the or each reinforcing element is adhered to the flexible material.

Advantageously the or each of the reinforcing element is formed of fabric.

Conveniently the or each reinforcing element is a region of adhesive which also bonds parts of the flexible material together to form the gas supply duct.

Preferably the or each aperture takes the form of a slit through the flexible material and the adhesive.

Conveniently the air-bag defines a plurality of inflatable regions or chambers.

Preferably the air-bag is an inflatable curtain, the gas supply duct being positioned to supply gas to each of the inflatable regions or chambers.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic side view of an air-bag in accordance with the invention without illustrating the reinforcement;

FIGURE 2 is a sectional view taken on the line II-II of Figure 1, showing the air-bag in an inflated condition;

FIGURE 3 is a side view and an underneath view of the gas supply duct of the air-bag of Figure 1, again without showing the reinforcement;

FIGURE 3a is an enlarged view of part of the gas duct of Figure 3 illustrating the yarn orientation in one embodiment of the invention;

FIGURE 3b is a view corresponding to Figure 3a illustrating the yarn orientation in an alternative embodiment of the invention;

FIGURE 4 is a view corresponding to Figure 3 showing one embodiment of a gas supply duct with reinforcement;

FIGURE 5 is a view corresponding to Figure 4 showing an alternative form of gas supply duct with reinforcement;

FIGURE 6 is a further view corresponding to Figure 4 showing yet another form of gas supply duct with reinforcement;

FIGURE 7 is an end view of a gas supply duct in accordance with another embodiment of the present invention, illustrating successive stages during manufacture;

FIGURE 8 is an underneath view of the gas supply duct illustrated in Figure 7, showing a plurality of apertures therein;

FIGURE 9 is a view corresponding generally to that of Figure 8, but illustrating an alternative embodiment, in which the gas supply gas duct is provided with a plurality of slits therethrough;

FIGURE 10 is a view corresponding generally to that of Figure 9, but illustrating the slits in a slightly opened condition representative of their condition upon inflation of the air-bag;

FIGURE 11 is a side view of a gas supply duct in accordance with a further embodiment of this present invention; and

FIGURE 12 is a view corresponding generally to that of Figure 11, illustrating a further variant of the gas supply duct.

Turning initially to Figures 1 to 3, an air-bag in accordance with the present invention is illustrated in the form of a so-called inflatable curtain 10. The inflatable curtain 10 is formed from two super-imposed layers of fabric 11, 12, of similar outer shape. The layers of fabric 11,12 are interconnected by

means of seams 13 which define inflatable regions 14, 15, 16. One of these inflatable regions 14 is sub-divided into inflatable chambers by means of seams 17 which interconnect the layers of fabric 11,12 within said inflatable region 14.

The present invention is not limited to the use of fabric, and the super-imposed layers may be formed from another suitable flexible material, for example plastic foil.

At one end of the lower edge of the inflatable curtain 10, as shown in Figure 1, a protruding strap 18 is provided, the strap 18 being adapted to be connected to an anchoring point in a vehicle. At the other end of the lower edge the inflatable curtain 10 a generally triangular extension 19 is provided which is also adapted to be connected to an anchoring point within the vehicle. The upper edge 20 of the inflatable curtain 10 is provided with a plurality of apertured mounting lugs 21 by means of which the inflatable curtain 10 may be mounted in position within a motor vehicle.

Extending adjacent the upper edge 20 of the inflatable curtain 10 there is provided an internal gas supply duct 22 of elongate form. The gas supply duct 22 is formed from a single element of fabric of elongate form which is folded about its axis so that the opposed side edges thereof are substantially super-imposed. The side edges of the fabric of the gas supply duct are inserted between the super-imposed upper side edges of the fabric layers 11 and 12 of the inflatable curtain 10, and the four super-imposed edges are interconnected by stitching 23 (see Figure 2). The lower-most part of the gas-supply duct 22 is provided with apertures 24 which are provided in those parts of the gas-supply duct which extend across the inflatable regions 14, 15, 16 of the inflatable curtain 10.

In use of the inflatable curtain 10, gas is supplied through the gas-supply duct 22 which becomes inflated, and the gas passes through the apertures 24 formed in the gas supply duct 22 into the inflatable regions 14, 15, 16 to cause those regions of the inflatable curtain 10 to inflate.

Figure 3 illustrates the gas supply duct 22, which is provided with apertures 24, from the side, and from below. As mentioned above, the gas supply duct is of elongate form and therefore defines elongate axis 25.

Figure 3 illustrates an area 26 of the fabric forming the gas supply duct 22 which is illustrated at an enlarged scale in Figures 3a and 3b which show alternate embodiments of the inventions.

Looking initially at Figure 3a, the warp and weft yarns of the fabric forming the gas supply duct 22 are shown. It can be seen that one set of yarns (i.e. either the warp or weft yarns) are co-aligned with the axis 25 and the other set of yarns are 90° to the axis 25.

Figure 3b shows an alternative arrangement in which the warp and weft yarns each make an angle of approximately 45° with axis 25.

It is thus to be understood that the yarns forming the fabric that constitutes the gas supply duct 22 may have any orientation with reference to the axis of the gas supply duct 22.

Whilst the gas supply duct 22 described so far is formed from a single element of fabric which is folded and sewn by stitching 23 to form the tubular gas supply duct 22, gas supply ducts for use with the present invention may be

formed as totally separate tubes or sleeves which are inserted into a pre-fabricated inflatable curtain.

As has been described above, if the yarns of the fabric are located so that one set of yarns are co-aligned with the axis 25 of the duct 22, the apertures 24 formed in the duct 22 may tear on inflation of the inflatable curtain 10. Alternatively, if the yarns are inclined at 45° to the axis 25 of the duct 22, should the gas supply duct 22 not be correctly positioned, the desired deformation of the fabric surrounding each aperture 24 may be blocked or restricted, for example by a dividing seam between two adjacent inflatable regions or chambers.

In embodiments of the present invention the fabric around at least one and preferably all of the gas outlet apertures 24 of the gas supply 22 are provided with a reinforcement to prevent tearing or deformation of the fabric surrounding the aperture.

Figure 4 illustrates an arrangement in which each aperture 24 within the gas supply duct 22 is provided with an annular reinforcing element 27 which is secured in position such that the central aperture of each annular element 27 is co-aligned with the respective aperture 24 formed in the fabric constituting the gas supply duct 22. Each annular element 27 may be mounted in position, for example, by the use of an adhesive, but may be secured in position using other techniques such as sonic welding.

Figure 5 illustrates a further embodiment of the invention wherein a single elongate reinforcing element 28 is provided, the element 28 having apertures 29 formed therein to be co-aligned with the apertures 24 formed in the fabric constituting the gas supply duct 22. Again the elongate reinforcing

element 28 may be secured in position by means of an adhesive or using other techniques such as sonic welding. The reinforcing elements shown in Figures 4 and 5 may be of fabric or other suitable material.

Figure 6 illustrates a further embodiment of the invention wherein each aperture 24 in the gas supply duct 22 is provided with stitching 30 around its outer periphery, the stitching constituting the reinforcement.

In each of the arrangements shown in Figures 4, 5 and 6 each aperture 24 provided within the gas supply duct 22 is provided with a reinforcement which reinforces the periphery of the aperture, thereby helping to prevent deformation or unwanted fraying of fabric in the region of the apertures during deployment of the air-bag.

Figure 7 illustrates three stages during the fabrication of an alternative form of gas supply duct in accordance with the present invention. Referring initially to Figure 7a, there is illustrated, from one end, an elongate, substantially rectangular, sheet of foil or the like 31. Along one longitudinal edge 32 of the foil 31, there is provided, on the upper surface of the foil, a region of adhesive 33. Along the opposing longitudinal edge 34 of the foil 31, another region of adhesive 35 is provided, but this region is provided on the under-surface of the foil 31, in the orientation illustrated in Figure 7a.

It will therefore be seen, having particular regard to Figure 7b, that the elongate piece of foil 31 can be rolled, as indicated by arrows A, such that the two longitudinal edge regions of the foil are superimposed on one another. As illustrated in Figure 7c, the two regions 33, 35 of adhesive are stuck to one another and hold the length of foil 31 in a substantially cylindrical, tubular configuration to define the resulting gas supply duct 36.

Figure 8 illustrates the resulting gas supply duct 36 from below, and the rectangular shaded area 37 represents the adhesive 33, 35 which holds the gas supply duct 36 together in the manner illustrated in Figure 7c. It will seen that a plurality of substantially equi-spaced apertures 38 are then cut through the two superimposed edge regions of the foil 31 and through the adhesive lying therebetween. The region of adhesive 37, when fully or substantially cured, serves as the reinforcement of the present invention, thereby preventing substantial deflection of a foil material 31 in the region of the apertures 38, and also preventing damage to the edges of the apertures 38 themselves.

Figure 9 illustrates a variant of the arrangement illustrated in Figure 8, in which, instead of providing a plurality of equi-spaced apertures in the form of substantially circular holes, the apertures which are cut through the superimposed edge regions of the foil material 31 and the adhesive 37, instead take the form of generally arcuate, narrow slits 39. The slits 39 are arranged in opposing pairs.

Because of the arcuate configuration of each slit 39, each slit defines a small outlet flap 40 which, in the condition illustrated in Figure 9, are substantially closed.

Figure 10 illustrates the arrangement shown in Figure 9 in the condition it adopts during inflation of the air-bag. It will be seen that each flap 40 is caused to open slightly under the action of the gas from the gas generator being forced through the slits 39.

The arrangement illustrated in Figures 9 and 10 is considered to be advantageous when compared to the arrangement of Figure 8 because by

cutting a plurality of slits through the foil material 31 and the adhesive 37, there is no, or at least significantly reduced, waste material when compared to the step of cutting out the circular apertures 38 in the Figure 8 embodiment. This means that manufacture of the arrangement illustrated in Figure 9 can more easily be automated than that of Figure 8, because there is less risk of waste material such as cut-out pieces of foil, block or jamming machinery.

Another advantage of the arrangement illustrated in Figures 9 and 10 is that, by careful orientation of the slits 39, the flaps 40 can be configured to protect regions of the inflatable curtain fabric lying immediately adjacent the gas supply duct, which is particularly advantageous because the gas flow exiting the apertures provided in the gas supply duct can be very aggressive.

Figure 11 illustrates a further proposed configuration for the gas supply duct, viewed from the side. The gas supply duct 41 of this arrangement is again provided with a plurality of substantially circular cut-out apertures 42 along its lower-most region, and it is envisaged that the supply duct 41 of this embodiment will be made from fabric material. The gas supply duct 41 is provided with a plurality of length of stitching 43, each of which is provided in the region of a respective aperture 42. The stitching 43 of each aperture 42 comprises a length of thread which extends from the fabric of the duct adjacent one side of the aperture and extends across the aperture to terminate in the fabric on the opposite side of the aperture 42. It will therefore be seen that each length of thread effectively ties together opposing parts of the or each aperture 42. This form of stitched reinforcement is mainly intended to avoid substantial deformation of the outlet apertures 42 during deployment of the air-bag, by preventing opposing parts of the apertures from moving away from one another during inflation.

Figure 12 illustrates a variant of the arrangement illustrated in Figure 11, in which a continuous line of stitching 44 is provided along the length of the gas supply duct 41 in regions between adjacent apertures 42, the thread of the stitching 44 is stitched through the fabric of the gas supply duct as a plurality of stitches, but in the region of each aperture 42, the thread extends across the apertures in substantially the same manner as described above with reference to Figure 11, again so as to serve to tie together opposing sides of the apertures 42. In this arrangement, it is envisaged that the line of stitching 44 could be used to hold together superimposed edge regions of a piece of fabric defining the gas supply duct 41.

In the present Specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".